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N° VI.

Description of a new STOVE for burning of Pitcoal, ana consuming all its Smoke.

BY DR. B. FRANKLIN.

Read January 28, 1786.

TOWARDS the end of the last century an ingenious French philosopher, whose name I am sorry I cannot recollect, exhibited an experiment to show that very offensive things might be burnt in the middle of a chamber, such as woollen rags, feathers, &c. without creating the least smoke or smell. The machine in which the experiment was made, if I remember right, was of this form, made of plate iron. Some clear burning charcoals were put into the opening of the short tube A, and supported there by the grate B. The air as soon as the tubes grew warm would ascend in the longer leg C and go out at D, consequently air must enter at A descending to B. In this course it must be heated by the burning coals through which it passed, and rise more forcibly in the longer tube in proportion to its degree of heat or rarefaction, and length of that tube. For such a machine is a kind of inverted syphon; and as the greater weight of water in the longer leg of a common syphon in descending is accompanied by an ascent of the same fluid in the shorter; so, in this inverted syphon, the greater quantity of levity of air in the longer leg, in rising is accompanied by the descent of air in the shorter. The things to be burned being laid on the hot coals at A, the smoke must descend through those coals, be converted into flame, which, after destroying the offensive smell, came out at the end of the longer tube as mere heated air.

Plate II.
Figure I.

H

Whoever

Whoever would repeat this experiment with success, must take care that the part A, B, of the short tube be quite full of burning coals, so that no part of the smoke may descend and pass by them without going through them, and being converted into flame; and that the longer tube be so heated as that the current of ascending hot air is established in it before the things to be burnt are laid on the coals; otherwise there will be a disappointment.

It does not appear either in the Memoirs of the Academy of Sciences, or Philosophical Transactions of the English Royal Society, that any improvement was ever made of this ingenious experiment, by applying it to useful purposes. But there is a German book, entitled *Vulcanus Famulans*, by Joh. George Leutmann, P. D. printed at Wirtemberg in 1723, which describes, among a great variety of other stoves for warming rooms, one which seems to have been formed on the same principle, and probably from the hint thereby given, though the French experiment is not mentioned. This book being scarce, I have translated the chapter describing the stove, viz.

“Vulcanus Famulans, by John George Leutmann, P. D.
“Wirtemberg, 1723.

“C H A P. VII.

“On a stove, which draws downwards.

“Here follows the description of a sort of stove, which
“can easily be removed and again replaced at pleasure.
“This drives the fire down under itself, and gives no
“smoke, but however a very unwholesome vapour.

“In the figure, A is an iron vessel like a funnel,
“nel, in diameter at the top about twelve inches,
“at the bottom near the grate about five inches;
“its height twelve inches. This is set on the barrel C,
“which is ten inches diameter and two feet long, closed
“at

Plate II.
Figure 20.

“ at each end E E. From one end rises a pipe or flue
 “ about four inches diameter, on which other pieces of pipe
 “ are set, which are gradually contracted to D, where the
 “ opening is but about two inches. Those pipes must to-
 “ gether be at least four feet high. B is an iron grate.
 “ F F are iron handles guarded with wood, by which the
 “ stove is to be lifted and moved. It stands on three legs.
 “ Care must be taken to stop well all the joints, that no
 “ smoke may leak through.

“ When this stove is to be used, it must first be carried
 “ into the kitchen and placed in the chimney near the fire.
 “ There burning wood must be laid and left upon its grate
 “ till the barrel C is warm, and the smoke no longer rises
 “ at A, but descends towards C. Then it is to be carried
 “ into the room which it is to warm. When once the
 “ barrel C is warm, fresh wood may be thrown into the
 “ vessel A as often as one pleases, the flame descends and
 “ without smoke, which is so consumed that only a va-
 “ pour passes out at D.

“ As this vapour is unwholesome, and affects the head,
 “ one may be freed from it, by fixing in the wall of the
 “ room an inverted funnel, such as people use to hang over
 “ lamps, through which their smoke goes out as through
 “ a chimney. This funnel carries out all the vapour cle-
 “ verly, so that one finds no inconvenience from it, even
 “ though the opening D be placed a span below the mouth
 “ of the said funnel G. The neck of the funnel is better
 “ when made gradually bending, than if turned in a right
 “ angle.

“ The cause of the draft downwards in the stove is the
 “ pressure of the outward air, which falling into the vessel
 “ A in a column of twelve inches diameter, finds only
 “ a resisting passage at the grate B, of five inches, and
 “ one at D, of two inches, which are much too weak
 “ to drive it back again ; besides, A stands much higher
 “ than B, and so the pressure on it is greater and more

“ forcible, and beats down the flame to that part where
“ it finds the least resistance. Carrying the machine first
“ to the kitchen fire for preparation, is on this account,
“ that in the beginning the fire and smoke naturally ascend,
“ till the air in the close barrel C is made thinner by the
“ warmth. When that vessel is heated, the air in it is
“ rarefied, and then all the smoke and fire descends
“ under it.

“ The wood should be thoroughly dry, and cut into
“ pieces five or six inches long, to fit it for being thrown
“ into the funnel A.” Thus far the German book.

It appears to me by Mr. Leutmann’s explanation of the operation of this machine, that he did not understand the principles of it, whence I conclude he was not the inventor of it; and by the description of it, wherein the opening at A is made so large, and the pipe E, D, so short, I am persuaded he never made nor saw the experiment, for the first ought to be much smaller and the last much higher, or it hardly will succeed. The carrying it in the kitchen, too, every time the fire should happen to be out, must be so troublesome, that it is not likely ever to have been in practice, and probably has never been shown but as a philosophical experiment. The funnel for conveying the vapour out of the room, would besides have been uncertain in its operation, as a wind blowing against its mouth would drive the vapour back.

The stove I am about to describe, was also formed on the idea given by the French experiment, and completely carried into execution before I had any knowledge of the German invention; which I wonder should remain so many years in a country where men are so ingenious in the management of fire, without receiving long since the improvements I have given it.

DESCRIPTION

DESCRIPTION of the PARTS.

A, the bottom plate which lies flat upon the hearth, with its partitions 1, 2, 3, 4, 5, 6, that are cast with it, and a groove Z Z, in which are to slide, the bottom edges of the small plates Y, Y, figure 12; which plates meeting at X close the front.

Plate II.
Figure 2.

B 1, figure 3, is the cover plate showing its under side, with the grooves 1, 2, 3, 4, 5, 6, to receive the top edges of the partitions that are fixed to the bottom plate. It shows also the grate W W, the bars of which are cast in the plate, and a groove V V, which comes right over the groove Z Z, figure 2, receiving the upper edges of the small sliding plates Y Y, figure 12.

B 2, figure 4, shows the upper side of the same plate, with a square impression or groove for receiving the bottom mouldings T T T T of the three sided box C, figure 5, which is cast in one piece.

D, figure 6, its cover, showing its under side with grooves to receive the upper edges S S S of the sides of C, figure 5, also a groove R, R, which when the cover is put on comes right over another Q Q in C, figure 5, between which it is to slide.

E, figure 7, the front plate of the box.

P, a hole three inches diameter through the cover D, figure 6, over which hole stands the vase F, figure 8, which has a corresponding hole two inches diameter through its bottom.

The top of the vase opens at O, O, O, figure 8, and turns back upon a hinge behind when coals are to be put in; the vase has a grate within at N N of cast iron H, figure 9, and a hole in the top one and a half inches diameter to admit air, and to receive the ornamental brass guilt flame M, figure 10, which stands in that hole and, being itself hollow and open, suffers air to pass through it to the fire.

G, figure 11, is a drawer of plate iron, that slips in between in the partitions 2 and 3, figure 2, to receive the falling

falling ashes. It is concealed when the small sliding plates Y Y, figure 12, are shut together.

I, I, I, figure 8, is a niche built of brick in the chimney and plastered. It closes the chimney over the vase, but leaves two funnels one in each corner communicating with the bottom box K K, figure 2.

DIMENSIONS of the PARTS.

	Feet.	In.
Front of the bottom box, - - -	2	0
Height of its partitions, - - -	0	$4\frac{1}{4}$
Length of N ^o 1, 2, 3 and 4, each, - -	1	3
Length of N ^o 5 and 6, each - -	0	$8\frac{1}{4}$
Breadth of the passage between N ^o 2 and 3, -	0	6
Breadth of the other passages each, -	0	$3\frac{1}{2}$
Breadth of the grate, - - -	0	$6\frac{1}{2}$
Length of ditto, - - -	0	8
Bottom moulding of box C, square, -	1	0
Height of the sides of ditto, - -	0	4
Length of the back side, - - -	0	10
Length of the right and left sides, each, -	0	$9\frac{1}{2}$
Length of the front plate E, where longest, -	0	11
The cover D, square, - - -	0	12
Hole in ditto, diameter, - - -	0	3
Sliding plates Y Y their length, each, -	1	0
-----their breadth, each, -	0	$4\frac{1}{2}$
Drawer G, its length, - - -	1	0
-----breadth, - - -	0	$5\frac{3}{4}$
-----depth, - - -	0	4
-----depth of its further end, only, -	0	1
Grate H in the vase, its diameter to the extremity of its knobs, - - -	0	$5\frac{3}{4}$
Thickness of the bars at top, - - -	0	$0\frac{1}{4}$
-----at bottom, less, -	0	0
Depth of the bars at the top, - - -	0	$0\frac{3}{4}$
Height of the vase, - - -	1	6
Diameter of the opening O, O, in the clear, -	0	8
	Diameter	

			Fect.	In.
Diameter of the air-hole at top,	-	-	0	1 $\frac{1}{2}$
—————of the flame hole at bottom,	-	-	0	2

To fix this Machine.

Spread mortar on the hearth to bed the bottom plate A, then lay that plate, level, equally distant from each jamb, and projecting out as far as you think proper. Then putting some Windfor loam in the grooves of the cover B, lay that on: Trying the sliding plates Y Y, to see if they move freely in the grooves Z Z, V V, designed for them.

Then begin to build the niche, observing to leave the square corners of the chimney unfilled; for they are to be funnels. And observe also to leave a free open communication between the passages at K K, and the bottom of those funnels, and mind to close the chimney above the top of the niche, that no air may pass up that way. The concave back of the niche will rest on the circular iron partition 1 A 4, figure 2, then with a little loam put on the box C over the grate, the open side of the box in front.

Then, with loam in three of its grooves, the groove R R being left clean, and brought directly over the groove Q Q in the box, put on the cover D, trying the front plate E, to see if it slides freely in those grooves.

Lastly, set on the vase, which has small holes in the moulding of its bottom to receive two iron pins that rise out of the plate D at I I, for the better keeping it steady.

Then putting in the grate H, which rests on its three knobs H H H against the inside of the vase, and slipping the drawer into its place; the machine is fit for use.

To use it.

Let the first fire be made after eight in the evening or before eight in the morning, for at those times and between those hours all night, there is usually a draft up a chimney, though it has long been without fire; but between those hours in the day there is often in a cold chimney

ney a draft downwards, when if you attempt to kindle a fire, the smoke will come into the room.

But to be certain of your proper time, hold a flame over the air-hole at the top. If the flame is drawn strongly down for a continuance, without whiffing, you may begin to kindle a fire.

First put in a few charcoals on the grate H.

Lay some small sticks on the charcoals,

Lay some pieces of paper on the sticks,

Kindle the paper with a candle,

Then shut down the top, and the air will pass down through the air-hole, blow the flame of the paper down through the sticks, kindle them, and their flame passing lower, kindles the charcoal.

When the charcoal is well kindled, lay on it the sea-coals, observing not to choak the fire by putting on too much at first.

The flame descending through the hole in the bottom of the vase, and that in plate D into the box C passes down farther through the grate W W in plate B 1, then passes horizontally towards the back of the chimney; there dividing, and turning to the right and left, one part of it passes round the far end of the partition 2, then coming forward it turns round the near end of partition 1, then moving backward it arrives at the opening into the bottom of one of the upright corner funnels behind the niche, through which it ascends into the chimney, thus heating that half of the box and that side of the niche. The other part of the divided flame passes round the far end of partition 3, round the near end of partition 4, and so into and up the other corner funnel, thus heating the other half of the box, and the other side of the niche. The vase itself, and the box C will also be very hot, and the air surrounding them being heated, and rising, as it cannot get into the chimney, it spreads in the room, colder air succeeding

ſucceeding is warmed in its turn, riſes and ſpreads, till by the continual circulation the whole is warmed.

If you ſhould have occaſion to make your firſt fire at hours not ſo convenient as thoſe above mentioned, and when the chimney does not draw, do not begin it in the vaſe, but in one or more of the paſſages of the lower plate, firſt covering the mouth of the vaſe. After the chimney has drawn a while with the fire thus low, and begins to be a little warm, you may cloſe thoſe paſſages and kindle another fire in the box C, leaving its ſliding ſhutter a little open; and when you find after ſome time that the chimney being warmed draws forcibly, you may ſhut that paſſage, open your vaſe, and kindle your fire there, as above directed. The chimney well warmed by the firſt day's fire will continue to draw conſtantly all winter, if fires are made daily.

You will, in the management of your fire, have need of the following implements :

A pair of ſmall light tongs, twelve or fifteen inches long, plate II, figure 13.

A light poker about the ſame length with a flat broad point, figure 14.

A rake to draw aſhes out of the paſſages of the lower plate, where the lighter kind eſcaping the aſh-box will gather by degrees, and perhaps once in a week or ten days require being removed, figure 15.

And a fork with its prongs wide enough to ſlip on the neck of the vaſe cover, in order to raiſe and open it when hot, to put in freſh coals, figure 16.

In the management of this ſtove there are certain precautions to be obſerved, at firſt with attention, till they become habitual. To avoid the inconvenience of ſmoke, ſee that the grate H be clear before you begin to light a freſh fire. If you find it clogged with cinders and aſhes, turn it up with your tongs and let them fall upon the grate below the aſhes will go through it, and the cinders may

be raked off and returned into the vase when you would burn them. Then see that all the sliding plates are in their places and close shut, that no air may enter the stove but through the round opening at the top of the vase. And to avoid the inconvenience of dust from the ashes, let the ash-drawer be taken out of the room to be emptied; and when you rake the passages, do it when the draft of the air is strong inwards, and put the ashes carefully into the ash-box, that remaining in its place.

If being about to go abroad, you would prevent your fire burning in your absence, you may do it by taking the brass flame from the top of the vase, and covering the passage with a round tin plate, which will prevent the entry of more air than barely sufficient to keep a few of the coals alive. When you return, though some hours absent, by taking off the tin plate and admitting the air, your fire will soon be recovered.

The effect of this machine, well managed, is to burn not only the coals, but all the smoke of the coals, so that while the fire is burning, if you go out and observe the top of your chimney, you will see no smoke issuing, nor any thing but clear warm air, which as usual makes the bodies seen through it appear waving.

But let none imagine from this, that it may be a cure for bad or smoky chimneys, much less, that as it burns the smoke it may be used in a room that has no chimney. 'Tis by the help of a good chimney, the higher the better, that it produces its effect; and though a flue of plate iron sufficiently high might be raised in a very lofty room, the management to prevent all disagreeable vapour would be too nice for common practice, and small errors would have unpleasing consequences.

It is certain that clean iron yields no offensive smell when heated. Whatever of that kind you perceive, where there are iron stoves, proceeds therefore from some foulness burning or fuming on their surface. They should
therefore

therefore never be spit upon, or greased, nor should any dust be suffered to lie upon them. But as the greatest care will not always prevent these things, it is well once a week to wash the stove with soap lees and a brush, rinsing it with clean water.

The Advantages of this Stove.

1. The chimney does not grow foul, nor ever need sweeping; for as no smoke enters it, no soot can form in it.

2. The air heated over common fires instantly quits the room and goes up the chimney with the smoke; but in the stove, it is obliged to descend in flame and pass through the long winding horizontal passages, communicating its heat to a body of iron plate, which having thus time to receive the heat, communicates the same to the air of the room, and thereby warms it to a greater degree.

3. The whole of the fuel is consumed by being turned into flame, and you have the benefit of its heat, whereas in common chimneys a great part goes away in smoke which you see as it rises, but it affords you no rays of warmth. One may obtain some notion of the quantity of fuel thus wasted in smoke, by reflecting on the quantity of soot that a few weeks firing will lodge against the sides of the chimney, and yet this is formed only of those particles of the column of smoke that happen to touch the sides in its ascent. How much more must have passed off in the air? And we know that this soot is still fuel; for it will burn and flame as such, and when hard caked together is indeed very like and almost as solid as the coal it proceeds from. The destruction of your fuel goes on nearly in the same quantity whether in smoke or in flame: but there is no comparison in the difference of heat given. Observe when fresh coals are first put on your fire, what a body of smoke arises. This smoke is for a long time too cold to take flame. If you then plunge a burning candle into it, the candle instead of inflaming the smoke will instantly

stantly be itself extinguished. Smoke must have a certain degree of heat to be inflammable. As soon as it has acquired that degree, the approach of a candle will inflame the whole body, and you will be very sensible of the difference of the heat it gives. A still easier experiment may be made with the candle itself. Hold your hand near the side of its flame, and observe the heat it gives; then blow it out, the hand remaining in the same place, and observe what heat may be given by the smoke that rises from the still burning snuff. You will find it very little. And yet that smoke has in it the substance of so much flame, and will instantly produce it, if you hold another candle above it so as to kindle it. Now the smoke from the fresh coals laid on this stove, instead of ascending and leaving the fire while too cold to burn, being obliged to descend through the burning coals, receives among them that degree of heat which converts it into flame, and the heat of that flame is communicated to the air of the room, as above explained.

4. The flame from the fresh coals laid on in this stove, descending through the coals already ignited, preserves them long from consuming, and continues them in the state of red coals as long as the flame continues that surrounds them, by which means the fires made in this stove are of much longer duration than in any other, and fewer coals are therefore necessary for a day. This is a very material advantage indeed. That flame should be a kind of pickle, to preserve burning coals from consuming, may seem a paradox to many, and very unlikely to be true, as it appeared to me the first time I observed the fact. I must therefore relate the circumstances, and shall mention an easy experiment, by which my reader may be in possession of every thing necessary to the understanding of it. In the first trial I made of this kind of stove, which was constructed of thin plate iron, I had instead of the vase a kind of inverted pyramid like a mill-hopper; and fearing at
first

first that the small grate contained in it might be clogged by cynders, and the passage of the flame sometimes obstructed, I ordered a little door near the grate, by means of which I might on occasion clear it. Though after the stove was made, and before I tried it, I began to think this precaution superfluous, from an imagination, that the flame being contracted in the narrow part where the grate was placed, would be more powerful in consuming what it should there meet with, and that any cynders between or near the bars would be presently destroyed and the passage opened. After the stove was fixed and in action, I had a pleasure now and then in opening that door a little, to see through the crevice how the flame descended among the red coals, and observing once a single coal lodged on the bars in the middle of the focus, a fancy took me to observe by my watch in how short a time it would be consumed. I looked at it long without perceiving it to be at all diminished, which surprised me greatly. At length it occurred to me, that I and many others had seen the same thing thousands of times, in the conservation of the red coal formed in the snuff of a burning candle, which while enveloped in flame, and thereby prevented from the contact of passing air, is long continued and augments instead of diminishing, so that we are often obliged to remove it by the snuffers, or bend it out of the flame into the air, where it consumes presently to ashes. I then supposed that to consume a body by fire, passing air was necessary to receive and carry off the separated particles of the body; and that the air passing in the flame of my stove, and in the flame of a candle, being already saturated with such particles, could not receive more, and therefore left the coal undiminished as long as the outward air was prevented from coming to it by the surrounding flame, which kept it in a situation somewhat like that of charcoal in a well luted crucible, which, though long kept in a strong fire, comes out unconsumed.

An

An easy experiment will satisfy any one of this conserving power of flame enveloping red coal. Take a small stick of deal or other wood the size of a goose quill, and hold it horizontally and steadily in the flame of the candle above the wick, without touching it, but in the body of the flame. The wood will first be inflamed, and burn beyond the edge of the flame of the candle, perhaps a quarter of an inch. When the flame of the wood goes out, it will leave a red coal at the end of the stick, part of which will be in the flame of the candle and part out in the air. In a minute or two you will perceive the coal in the air diminish gradually, so as to form a neck; while the part in the flame continues of its first size, and at length the neck being quite consumed it drops off; and by rolling it between your fingers when extinguished you will find it still a solid coal.

However, as one cannot be always putting on fresh fuel in this stove to furnish a continual flame as is done in a candle, the air in the intervals of time gets at the red coals and consumes them. Yet the conservation while it lasted, so much delayed the consumption of the coals, that two fires, one made in the morning, and the other in the afternoon, each made by only a hatfull of coals, were sufficient to keep my writing room, about sixteen feet square and ten high, warm a whole day. The fire kindled at seven in the morning would burn till noon; and all the iron of the machine with the walls of the niche being thereby heated, the room kept warm till evening, when another smaller fire kindled kept it warm till midnight.

Instead of the sliding plate E, which shuts the front of the box C, I sometimes used another which had a pane of glass, or, which is better, of Muscovy talc, that the flame might be seen descending from the bottom of the vase and passing in a column through the box C, into the cavities of the bottom plate, like water falling from a funnel, admirable to such as are not acquainted with the nature of the machine, and in itself a pleasing spectacle.

Every

Every utensil, however properly contrived to serve its purpose, requires some practice before it can be used adroitly. Put into the hands of a man for the first time, a gimblet or a hammer, (very simple instruments) and tell him the use of them, he shall neither bore a hole or drive a nail with the dexterity or success of another who has been a little accustomed to handle them. The beginner therefore in the use of this machine, will do well not to be discouraged with little accidents that may arise at first from his want of experience. Being somewhat complex, it requires as already said a variety of attentions; habit will render them unnecessary. And the studious man who is much in his chamber, and has a pleasure in managing his own fire, will soon find this a machine most comfortable and delightful. To others who leave their fires to the care of ignorant servants, I do not recommend it. They will with difficulty acquire the knowledge necessary, and will make frequent blunders that will fill your room with smoke. It is therefore by no means fit for common use in families. It may be adviseable to begin with the flaming kind of stone coal, which is large, and, not caking together, is not so apt to clog the grate. After some experience, any kind of coal may be used, and with this advantage, that no smell, even from the most sulphurous kind can come into your room, the current of air being constantly into the vase, where too that smell is all consumed.

The vase form was chosen as being elegant in itself, and very proper for burning of coals: Where wood is the usual fuel, and must be burnt in pieces of some length, a long square chest may be substituted, in which A is the cover opening by a hinge behind, B the grate, C the hearth box with its divisions as in the other, D the plan of the chest, E the long narrow grate. This I have not tried, but the vase machine was completed in 1771, and used by me in London three winters, and one afterwards in America, much to my satisfaction; and I have not yet

thought

Plate 2.
Figure 17.

thought of any improvement it may be capable of, though such may occur to others. For common use, while in France, I have contrived another grate for coals, which has in part the same property of burning the smoke and preserving the red coals longer by the flame, though not so completely, as in the vase, yet sufficiently to be very useful, which I shall now describe as follows.

A, is a round grate, one foot (French) in diameter, and eight inches deep between the bars and the back; the sides and back of plate iron; the sides having holes of half an inch diameter distant 3 or 4 inches from each other, to let in air for enlivening the fire. The back without holes. The sides do not meet at top nor at bottom by eight inches: that square is filled by grates of small bars crossing front to back to let in air below, and let out the smoke or flame above. The three middle bars of the front grate are fixed, the upper and lower may be taken out and put in at pleasure, when hot, with a pair of pincers. This round grate turns upon an axis, supported by the crotchet B, the stem of which is an inverted conical tube five inches deep, which comes on as many inches upon a pin that fits it, and which is fixed upright in a cast iron plate D, that lies upon the hearth; in the middle of the top and bottom grates are fixed small upright pieces E E about an inch high, which as the whole is turned on its axis stop it when the grate is perpendicular. Figure 19 is another view of the same machine. Plate 2.
Figure 18.

In making the first fire in a morning with this grate, there is nothing particular to be observed. It is made as in other grates, the coals being put in above, after taking out the upper bar, and replacing it when they are in. The round figure of the fire when thoroughly kindled is agreeable, it represents the great giver of warmth to our system. As it burns down and leaves a vacancy above, which you would fill with fresh coals, the upper bar is to be taken out, and afterwards replaced. The fresh coals while the grate

grate continues in the same position, will throw up as usual a body of thick smoke. But every one accustomed to coal fires in common grates, must have observed that pieces of fresh coal stuck in below among the red coals have their smoke so heated as that it becomes flame as fast as it is produced, which flame rises among the coals and enlivens the appearance of the fire. Here then is the use of this swivel grate. By a push with your tongs or poker, you turn it on its pin till it faces the back of the chimney, then turn it over on its axis gently till it again faces the room, whereby all the fresh coals will be found under the live coals, and the greater part of the smoke arising from the fresh coals will in its passage through the live ones be heated so as to be converted into flame: Whence you have much more heat from them, and your red coals are longer preserved from consuming. I conceive this construction, though not so complete a consumer of all the smoke as the vase, yet to be fitter for common use, and very advantageous. It gives too a full sight of the fire, always a pleasing object, which we have not in the other. It may with a touch be turned more or less from any one of the company that desires to have less of its heat, or presented full to one just come out of the cold. And supported in a horizontal position, a tea-kettle may be boiled on it.

The author's description of his Pennsylvania fire-place, first published in 1744, having fallen into the hands of workmen in Europe, who did not, it seems, well comprehend the principles of that machine, it was much disguised in their imitations of it; and one of its main intentions, that of admitting a sufficient quantity of fresh air warmed in entering through the air-box, nearly defeated, by a pretended improvement, in lessening its passages to make more room for coals in a grate. On pretence of such improvements, they obtained patents for the invention, and for a while made great profit by the sale, till the public became sensible of that defect, in the ex-

pected operation. If the same thing should be attempted with this safe stove, it will be well for the buyer to examine thoroughly such pretended improvements, lest, being the mere productions of ignorance, they diminish or defeat the advantages of the machine, and produce inconvenience and disappointment.

The method of burning smoke, by obliging it to descend through hot coals, may be of great use in heating the walls of a hot-house. In the common way, the horizontal passages or flues that are made to go and return in those walls, lose a great deal of their effect when they come to be foul with soot; for a thick blanket-like lining of soot prevents much of the hot air from touching and heating the brick work in its passage, so that more fire must be made as the flue grows fouler: But by burning the smoke they are kept always clean. The same method may also be of great advantage to those businesses in which large coppers or caldrons are to be heated.

Written at Sea, 1785.

N^o VII.

A Theory of Lightning and Thunder Storms, by ANDREW OLIVER, Esq. of Salem in the State of Massachusetts.

Read January, 1774.

IT has been generally, and, considering the phenomena themselves, very naturally supposed, that the electric charges which are exhibited in repeated flashes of lightning during a thunder storm, are previously accumulated in the vapors which constitute the cloud; and that these vapors, when by any means they become either over-charged with electric matter, or are deprived of their
natural

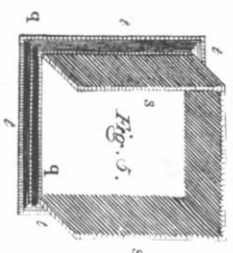
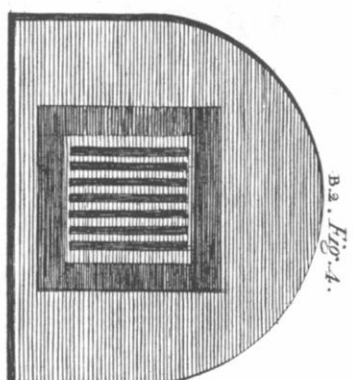
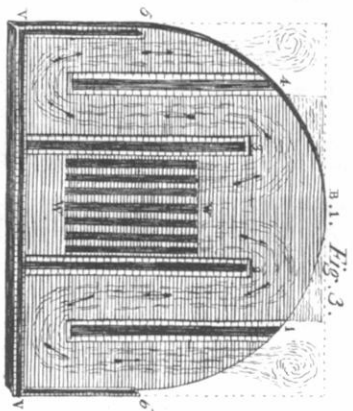
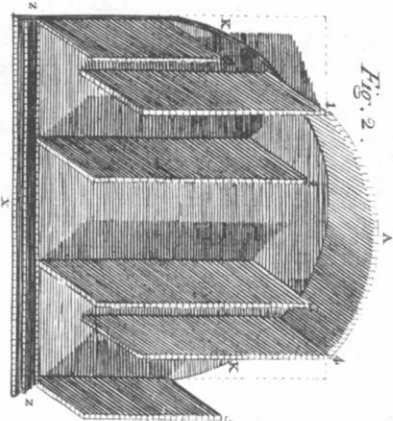
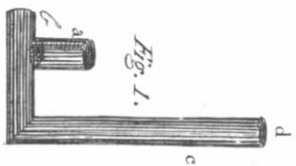


Fig. 5.

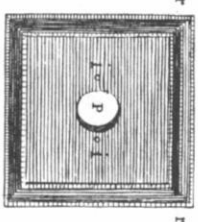


Fig. 6.

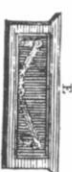


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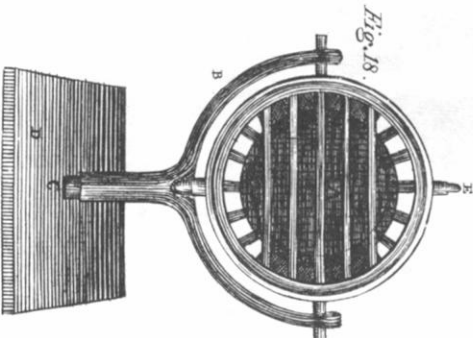


Fig. 8.

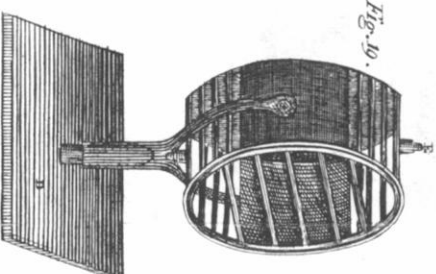


Fig. 9.

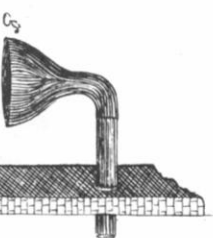


Fig. 10.

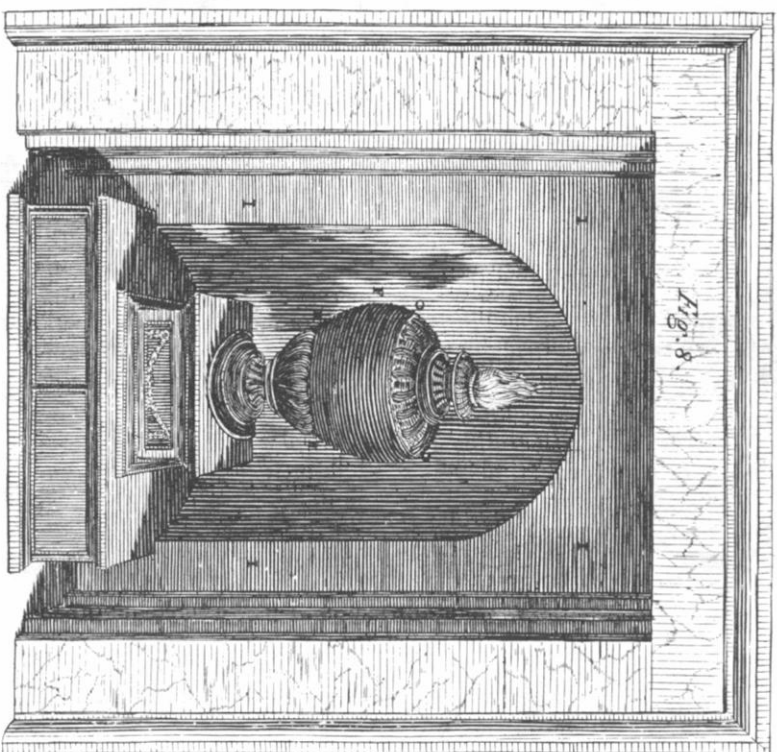


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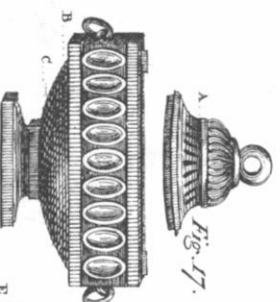


Fig. 12.



Fig. 13.

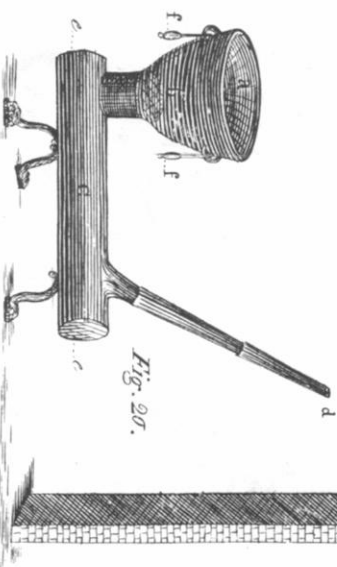


Fig. 14.



Fig. 15.

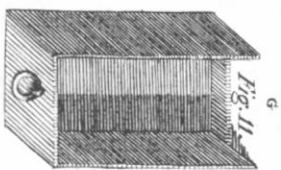


Fig. 16.



Fig. 17.

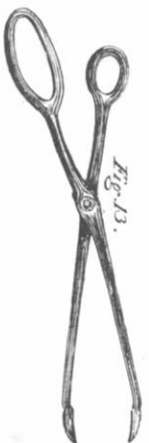


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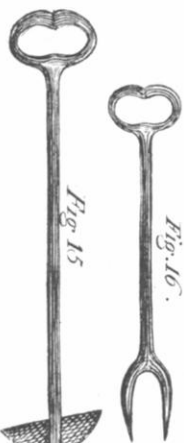


Fig. 19.

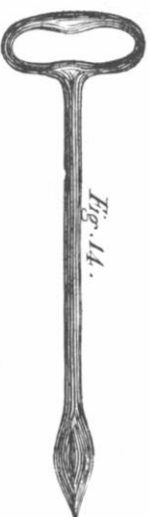


Fig. 20.